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# Dynamic pricing and asymmetries in retail gasoline markets: What can they tell us about price stickiness?

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## HIGHLIGHTS

- We test theories of price stickiness in retail gasoline prices.
- We utilize a data set of prices for individual retail stations.
- Stations price asymmetrically "in the large" but not "in the small".
- Cost decreases with lower cost volatility tend to result in lower retail prices.
- These results are consistent with fair pricing and rational producer inattention.

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## ABSTRACT

Theoretical explanations for price stickiness used in businesses cycle models are diverse (e.g., information processing delays, rational inattention and fair pricing), with each theory resulting in a different implication for inflation dynamics. Using an autoregressive conditional binomial model and a data set consisting of daily observations of price and cost for 15 Philadelphia retail gasoline stations, we test which of these theories is most consistent with the observed pattern of price adjustment. Our findings of time dependence, asymmetry and the role of cost volatility are consistent with a combination of fairness considerations and rational inattention by producers.



## 1. Introduction

Business cycle models often rely on the assumption that prices adjust infrequently – due to market frictions – in order to generate the short-run non-neutrality of money documented in the empirical macroeconomic literature (Sims, 1992).[1] While on the surface, the difference between alternative theories (e.g., information processing delays, rational inattention, fair pricing) might seem slight, each motivation has different implications for inflation dynamics (Reis, 2006). Understanding the nature and extent of price stickiness is important for conducting macroeconomic and monetary policy. Moreover, studying the prevalence and form of time dependence in micro level data on price changes can aid in choosing among alternative models of price stickiness.

In this study, we utilize daily retail gasoline prices from Philadelphia, PA, to inquire whether the empirical implications of some price adjustment models are borne out by micro level data on price changes. In particular, is a firm more likely to change its price if it changed its price on the previous day? Does the history of prices matter for the probability of a price change only through changes in costs the firm faces? Are periods of higher than average cost volatility more likely to result in changes in retail gasoline prices? Answering these questions is key because each theory of price stickiness implies a different combination of three elements: (i) a specific form of time dynamics in the firm's price change decision, (ii) the presence or absence of asymmetry in the pattern of price adjustment, and (iii) significance of other explanatory variables such as changes in cost or cost volatility. Whereas the vast

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[1] Examples include: Rotemberg and Woodford (1997), Clarida et al. (1999), Chari et al. (2000), Erceg et al. (2003) and Dotsey and King (2006).

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**Table 1**
Summary statistics.

| Station | Mean price | Mean wholesale | Mean excess volatility | Frequency of price change | Frequency of wholesale price change |
|---|---|---|---|---|---|
| 1 | 165.82 | 100.57 | 0.426 | 0.069 | 0.366 |
| 2 | 162.48 | 100.52 | 0.278 | 0.104 | 0.363 |
| 3 | 161.96 | 100.53 | 0.002 | 0.106 | 0.357 |
| 4 | 162.61 | 100.57 | 0.316 | 0.102 | 0.361 |
| 5 | 160.17 | 100.58 | 0.003 | 0.092 | 0.360 |
| 6 | 162.06 | 100.59 | 0.257 | 0.085 | 0.363 |
| 7 | 160.48 | 100.60 | 0.143 | 0.107 | 0.367 |
| 8 | 163.29 | 100.65 | 0.002 | 0.085 | 0.359 |
| 9 | 164.90 | 100.59 | 0.182 | 0.090 | 0.378 |
| 10 | 163.03 | 100.72 | 0.153 | 0.107 | 0.366 |
| 11 | 162.79 | 100.59 | 0.201 | 0.097 | 0.378 |
| 12 | 164.39 | 100.61 | 0.256 | 0.112 | 0.362 |
| 13 | 156.29 | 99.46 | −0.002 | 0.136 | 0.401 |
| 14 | 158.60 | 100.69 | 0.002 | 0.124 | 0.364 |
| 15 | 161.60 | 100.63 | 0.138 | 0.106 | 0.348 |

Note: All prices are given in cents/gallon.

majority of the empirical gasoline literature investigates the speed of pass-through from wholesale costs to retail gasoline prices and the asymmetric nature of price adjustments,[2] we focus on the discrete nature of price changes.

We extend the work of Davis and Hamilton (2004), Douglas and Herrera (2010), and Davis (2007). The first two articles study stickiness in Philadelphia's wholesale prices, whereas the latter studies Newburgh's, NY, retail gasoline prices. Davis and Hamilton (2004) and Davis (2007) estimate an autoregressive conditional hazard (ACH) model. Instead we use an autoregressive conditional binomial (ACB) model, which enables us to test for richer patterns of time-dependence than the ACH model. The ACB has been used by Douglas and Herrera (2010) to examine wholesale gasoline prices; thus it appears natural to extend this framework to retail gasoline prices. Furthermore, our work departs from the above mentioned studies in two aspects: (i) we directly observe the change in the price of wholesale gasoline (i.e., the change in the station's marginal cost) instead of having to impute the price-cost gap, and (ii) we study the role of cost volatility in determining the probability of price changes.

Our results suggest that the dynamics of price adjustment in Philadelphia's retail gasoline market have three characteristics. First, stations are more likely to make retail price decreases compared to retail price increases in response to small cost changes; a result that is consistent with the idea of "fair pricing". Second, stations are more likely to make retail price increases than retail price decreases in response to larger cost changes. Last but not least, stations are somewhat more likely to drop their price when a cost decrease is associated with higher cost volatility. This behavior is supportive of "rational inattention."

The paper is organized as follows. Section 2 describes the data. Section 3 presents the ACB model and the testable predictions. Section 4 expounds the results and Section 5 concludes.

## 2. Data

Daily retail and wholesale gasoline prices for 15 retail gasoline stations in Philadelphia, PA, spanning January 1, 2002 to December 31, 2004 were obtained from the Oil Price Information Service. The retail price is recorded whenever a fleet card is used to purchase gasoline. The wholesale price is recorded as the posted price at the wholesale terminal closest to the retail station. Fleet cards pose an issue: if no fleet card transaction takes place, then the observation for that day is coded as missing. We follow Davis (2007) and impute the last value observed to each daily unobserved data point. Since the average length of the missing periods is 1.7 days, and 74% of the missing periods in the data set have the same price before and after, we do not believe the missing observations pose a problem.

This data set provides a good testing ground for various reasons. First, retail gasoline sold in Philadelphia is a chemically homogeneous good,[3] which minimizes the influence of product heterogeneity on the pattern of price adjustments. Second, the price of wholesale gasoline accounts for about 85% of the retail price, with the remaining 15% coming from labor costs and transportation costs of delivering gasoline from the wholesale terminal to the retail outlet. Because Philadelphia has a wholesale terminal, differences in transportation costs should be minimal. Third, since retail gasoline is sold in standardized lots of one gallon, sellers cannot reduce quantity in lieu of raising price. Fourth, price stickiness is evident in that changes in retail gasoline prices take place only at particular points in time and often remain unchanged in the face of observable cost changes. As seen in Table 1, the retail price of gasoline changed on less than 14% of the days, whereas the wholesale price (i.e., the main input cost) changed on approximately 40% of the days. Finally, changes in retail gasoline prices appear to have distinct dynamics with price movements being more likely followed by movements in the same direction.[4]

## 3. ACB model and testable predictions

Let $x_{t+1}$ be a binary variable that takes the value of unity if a price change is observed on day $t+1$ and $\mathbf{z}_t$ is a vector of exogenous variables known at time $t$. Define $h_{t+1}$ as the probability that a station changes its price on day $t+1$ as:

$$h_{t+1} \equiv prob\left(x_{t+1} = 1 \mid x_t, x_{t-1}, \ldots, x_1, \mathbf{z}_t\right). \quad (1)$$

Let $G(\cdot)$ be a strictly increasing, continuous c.d.f. such as the logistic c.d.f. Since $G(\cdot)$ is strictly increasing, $G^{-1}(h_{t+1})$ is a link function that is well-defined by $G^{-1}(h_{t+1}) = y_t \iff G(y_t) = h_{t+1}$, or $G^{-1}(\cdot)$ is a 1-1 mapping from $h_{t+1}$ to $\mathbb{R}$. Then, the ACB model is given by

$$G^{-1}(h_{t+1}) = \omega + \sum_{j=1}^{q} \alpha_j \left(x_{t-j+1} - h_{t-j+1}\right) + \sum_{j=1}^{r} \beta_j G^{-1}\left(h_{t-j+1}\right) + \sum_{j=1}^{s} \delta_j x_{t-j+1} + \gamma \mathbf{z}_t. \quad (2)$$

[2] See, e.g., Borenstein et al. (1997).

[3] The local regulation supplementary to the Clean Air Act Amendments of 1990 is the same for the whole city.

[4] For all firms, the percentage of price changes that followed a price change of the same sign exceeds 70%.